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ABSTRACT

This paper provides data and opinions on long- and short-term challenges and changes required to meet the human resource and educational needs in a nuclear electric era as seen from a utility company's point of view. In particular, statements on engineering education curriculum, statistics on certain future manpower requirements, electric utility problems and needs, and a research and development program supported by utility companies and directed at important energy problems are detailed. (CP)

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ENERGY: EDUCATION AND INDUSTRY CHANGES FOR A NEW ERA

UTILIZATION SYSTEM MODIFICATIONS

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Introduction

Union Electric is pleased to participate in this EEI-ASEE panel discussion and to share opinions and data on the important topic of engineering manpower utilization and related engineering educational changes that may be desired.

Whatever the present situation is or the future holds for engineers, discussions of this type which allow for the gathering of actual facts, for responsible projections, and for general interchange are necessary for all of us, individually and collectively.

In the comments that follow, an effort will be made to respond to the guideline suggestions that were supplied by EEI and ASEE to all panel participants. These guidelines ask for data and opinions on long and short term challenges and changes required to meet the human resource and education needs in the coming nuclear electric economy era. Specifically the viewpoint of a user will be presented herein.

On the Need for Specialization - Academic Content

In evaluating this response to the suggested monumental topic regarding future changes in the education and utilization of engineers, it should be recognized that Union Electric has probably represented one of the more stable segments of engineering employers from

a numerical point of view as well as degree type over the past few decades. Hence our past record has been quite uniform and predictable; however, the future promises change as new technological challenges, as never before, are facing the utilities in many areas--such as the need for new fuels and the demands for cleaner air, cooler water, and more beautiful physical systems. In addition, social, governmental, and political forces are interacting with the utility business with new vigor.

Some Comments on Academic Specialization

From within the general field of engineering, it has been and will continue to be difficult to predict even for a utility what specialities such as power, electronics, structures, controls, chemical, networks, nuclear, systems, thermo, communications, bio, computers, electromagnetics, and instrumentations will be most needed and by whom. To be a little more specific regarding the difficulty, considering just the subfield of power, predictions on specialization for the demands of a particular company or industry are risky. For example, one perhaps could think of power as being traditional large alternators, large transformers, or large transmission systems; however, power now and in the very near future could also mean direct energy conversion, AC machinery using superconductors, fission, fusion, or perhaps sea thermal devices from among many possibilities. However, even within the more routine part of the utility operation, the value of a particular specialty within engineering for a young graduate is somewhat moot, say, compared to the overall quality, character, and attitude of the individual.

Continuing, the student should be thoroughly educated in the more general concepts and ideas associated with engineering such as analysis, experimentation and design, and he should be alerted to the value of and need to apply various kinds of mathematics to a range of engineering-type problems.

Certainly in the utilities there is a need for specialists and a general need to be aware of such specialities and the best place perhaps for young engineers to get introductory information in these multiple areas is at the university so as to enhance his effectiveness in industry. Conversely, all too often the young engineer in industry may accept employment in a fairly specialized area of engineering and then may not recognize opportunities to obtain meaningful exposure to other areas of specialization.

To the extent that some specialization is helpful as a motivator for students and faculty, as a teaching aid, or in research, it of course is desirable. However, because of the great uncertainty regarding the professional future of any one individual engineer, it appears that university emphasis should be on educated engineers who are broadly based. Specialization for the sake of specialization within a given field of engineering at the university level may be premature and appears to have certain drawbacks, especially if future employment is the primary motivator for such specialization.

On the Need for Specialization - Job Function

From a functional point of view, engineers may, for example, serve in design, development, research, operations, marketing, and manufac-

turing. Traditionally electric utilities have utilized electrical and mechanical engineers most heavily in design, operations, and marketing, while they in turn have been dependent on other organizations for the most part for support in research, development, and manufacturing.

However, in recent years the increased national concern for conservation of our resources and environment has caused a dramatic change in attitude and activities on the part of electrical utilities, among others, regarding research and development. Hundreds of millions of dollars are now being set aside each year by the utilities for more broadly based research and development. In the main, the research is and will be funded and directed by utilities; however, it is and will be generally performed by non-utility groups such as electrical manufacturers and universities. Thus, while there will be a continuing increase in engineers employed to perform utility research, much of the hiring will be done by non-utility groups who are members of the power industry. The scope and content of the research programs will be discussed later.

In any event engineering curricula and individual programs and counselors should not try to aim a young student at a specific functional target for some 3, 5, or 20 years later. Only the future possibility of such types of endeavor should be strongly acknowledged during the academic career of the student as part of a well-rounded educational program.

Engineering Manpower Requirements

As mentioned in the preceding section, utilities are embarking on very large research and development programs and the amount of money being spent is increasing from relatively small amounts to hundreds of millions of dollars per year. However, aside from this research program, the uti.ity engineering requirements tend to remain fairly stable even though the number of plants and the generating capacity continue to increase rapidly. More efficient and better engineering design, better instruments, and better control systems tend to neutralize the need for corresponding increases in the number of engineering personnel required.

Thus the traditional engineering at the utilities tends not to produce requirements for substantial additional engineering manpower. In fact, the past 10-year record at Union Electric has been one of slightly decreasing requirements for engineers in spite of exponential growth in electrical generating capacity and energy delivered.

At Union Electric 22 engineers were hired during the 74-75 year while 39 had been hired during 73-74. The above decline matches figures released by the College Placement Council [1] which indicate that engineering "hires" are down at all degree levels for 74-75. Engineering hires were down 20% at the BS level, 23% at MS level, and 10% at the PhD level. Utilities and transportation overall hires were down 45% according to the same report. Overall manufacturing and industrial hires showed a sharp decline in 74-75 in all categories except petroleum which was up 4%. It is pointed out that the declines in engineering hires follow three years of increases.

During 74-75 utilities' offers to engineers exceeded all other degree categories by large numbers, and within the engineering field electricals led the way with civil second and mechanical third.[2]

Data from an old Electric Utility Manpower Survey, which was conducted by Edison Electric Institute during 1971, are shown as Exhibits A and B.[3] These data were probably the most reliable that were available at the time regarding electric utilities and convey an impression of utility hiring patterns. They may change abruptly in the near future as the full impact of research and development programs materializes, although other forces at work will tend to neutralize the R & D impacts.

More on Engineering Manpower Requirements

From a slightly different point of view, there is much discussion today regarding the demand for engineers. There are two points that should be made in regard to the current situation:

a) Much of the news reporting and interpreting seems to be done by groups and individuals who are not part of the engineering profession and it appears to this speaker that there is much distortion in the reports, possibly just for the sake of news. While opportunities for engineers may vary, it is still perhaps the field with the greatest employment opportunity for the coming years. For example, it seems foolish to counsel a student away from engineering because of a given employment situation into, say, liberal arts where the opportunities seem to be uniformly poor.

b) Also there is much discussion about the employability and flexibility of young engineers, especially those who have achieved advanced degrees. Many people have said that they prefer to hire engineers at the lower degree levels because, they say, the young Ph.D. thinks that he must spend the rest of his life working in the area of his dissertation at a high salary. This is an unfortunate attitude, and to the extent that it is true with our young Ph.D's, should be corrected. While very demanding and highly specialized work is required, the specialization is in many fields which change continuously with time. Thus, all engineers at all degree levels need to develop a maturity that allows them to adapt to changing conditions and changing problems.

It appears that there will always be problems requiring maximum knowledge, ability and dedication and hence a need for highly educated engineers. It is only if the more highly educated have some other kind of drawback that they would be less desirable and employable than the less educated individuals. Thus a mature flexible engineer with a doctorate should always be more employable than a comparable individual with the B.S. or M.S.

Regarding employment for engineers generally, perhaps the high employment rate of the last 30 years has produced some "fat cats", a certain amount of indifference and carelessness, and a lack of concern.

Some of the present finger pointing and criticism of engineering could have been avoided if more engineers, including faculty, participated in professional and civic groups which actually work in

important problem areas. While trips to present a scholarly paper are excellent, perhaps enjoyable, and important; the value of saving a run down city or of providing material, educational, or spiritual hope to our poor is inestimable. Engineers have an important segment of the expertise required to solve some of these vast problems of society which to date seem only to grow worse in the hands of various agencies and political groups. Attention to this type of opportunity is urged.

Regarding Content of Engineering Curricula - General

As the educators know better than almost anyone else, the subject of curricula has been discussed almost continuously by faculties and others for many years. Curricula cycle with time as apparent weaknesses or flaws are detected, and at any one time a wide range of options exists from school to school depending on the faculty interests and geographical location. Thus this report will not attempt to analyze a particular curriculum and its requirements but will offer several opinions as to what a given curriculum should provide for the student at each of the three degree levels.

The general ECPD guidelines for undergraduate engineering curricula appear to be reasonably satisfactory. These general guidelines tend to guarantee a fairly broad general education which perhaps could be classed as the most broadening undergraduate program available. Generally in view of the nature of our society today and of the technological achievements of man through the years, the engineer is able to cope with the modern developments while at the same

time being somewhat familiar with the other endeavors of man because of his elementary, high school, liberal arts portion of his B.S. degree work, and everyday living. Thus, while the overwhelming emphasis in the engineering profession has been on education for somewhat specialized employment in a subfield of engineering, it is the writers' opinion that a more important consideration is that the engineer has a very broad liberal education in its own right, independent of employment opportunities. It is this thought that reduces the concern of the writers over specialization within engineering at the B.S. level. Thus while a B.S.E.E., for example, has the option of specialized employment in his field, he can with relative ease continue his education in law, medicine, math, etc., or he can find more general employment readily.

Regarding Engineering Curricula - B.S. Level

To provide some viewpoint with regard to curricula however the writers suggest that all engineers be required:

a) To study mathematics through differential equations, numerical methods, and probability and statistics. The jurisdictional or course arrangement for these materials is left to the faculty of the individual school.

b) To become sufficiently familiar with computers to recognize that they are electronic hardware systems that utilize extensive soft ware and which they may someday design. Their study should include

analogue, digital, and various hybrid categories, the introduction to the need for new number systems such as binary, and the introduction to the requirement for the concept of logical design. Further, the student should be aware of the fact that computers require programming and that they do not automatically solve all of man's problems or do anything that is not programmed. Students should be impressed with the fact that computers provide high speed computation and data handling and as such provide a valuable tool for engineers among others. Correspondingly optimal utilization of computers is achieved only by highly informed individuals who exercise perseverence and fortitude. This relatively new dimension in engineering problem solving and plant operation has imposed an additional problem of potential obsolence on many engineers and at the same time has opened the doors for immensely greater achievement.

To the extent possible, some detailed information and some perspective regarding computers and their use should be implemented.

c) To become familiar with the concept of engineering design as opposed to sterile analysis, memorization of facts, or routine experimentation. The obvious difficulties associated with the immaturity of young people and the lack of time for extensive design projects is thoroughly appreciated. The area of design specialization should be solely at the interest of the student and under the jurisdiction of the appropriate faculty or department and should be selected for its reasonability and feasibility as a student project. If projects or topics can be solicited conveniently from industry with appropriate support, certainly there would be no objection as long as

the goals of a good education for the student are not lost. Obviously inputs from industry can serve to make university work more meaningful.

d) To meet certain nontechnical requirements. Regarding such courses as management, social-humanistic, communication skills, and economics along with many other possibilities, it is the writers' opinion that in general engineering curricula are well balanced in this regard and that the schools within the ECPD guidelines are providing sound educational programs within the present time constraints.

To the degree possible each of your faculty should strive for educational excellence and should involve the student in a personal way in many aspects of the university operation. This concept may include large lecture classes wherein there is little class interaction; but, it should also involve the students in projects, organizations and even in the university structure. Many of the general facets of liberal education for worthwhile living are best learned by involvement in organizations as opposed to routine classroom work on how to give a speech or how to manage effectively.

A suggested guideline for a 4-year engineering curriculum is to insist that the student learn in school those things which he is least likely to learn on his own. This learning in turn will take place in a spectrum of activities from formal classes to individual projects to informal discussion.

The writers feel that the student is least likely to learn on his own such things as mathematic requirements previously outlined, electrical engineering theories and designs as covered by most accredited curricula, and a strong background in related sciences

such as biology, chemistry, and physics. On the other hand, an alert and intellectually able student can and will adjust to his environment and find auxiliary courses as required. He may, for example, attend special seminars on various economic theories, learn methods for predicting the stockmarket, learn the rules on how to make an effective speech or teach a course. The intention here is to state that certain art forms and individual traits are best learned and developed by the individual as opposed to being taught by some arbitrarily selected teacher. They do not constitute a first formal requirement for an engineering curriculum. Stated in another way, the speaker sees no need for an engineering student to take two, three, four, or more courses in report writing or speech in the Arts school at the cost of sacrificing hard core engineering, science, and mathematic courses; but, rather the bulk of the speech and communication work for the engineering student should be incorporated into his regular course work. Such goals obviously require a dedicated, attentive, sympathetic and capable faculty.

Regarding Splintering of Undergraduate Engineering Curricula

Regarding curricula and university structures, it appears that universities as many other organizations have political problems and power struggles. Concomitantly they introduce new names and new curricula in response to current events and public fads. It is the writers' opinion that substantial long-term curricula need not follow every new idea, device, or agency. For example, in recent years new curricula and new programs were instituted in response to the development of electronic computers, space capsules, and nuclear power plants.

In this regard, the need for broad but rigorously educated young engineers seems to work against new and hastily organized curricula that are narrowly orientated. All engineering graduates for example should be required to learn certain materials which have been defined as basic and fundamental such as electrical circuits, electronics, stress, force systems, and thermodynamics.

With this thought in mind, the merit of special curricula or degree programs in nuclear engineering or computer science is highly debatable. From the utility point of view, the nuclear portion of the system represents but a small fraction of the total system in academic content, in dollar value, and in design capability requirements and even the nuclear portion depends to a great degree on material that has been previously taught in well-established courses in chemistry, physics, and engineering.

Considering the computer, if it is viewed as a somewhat extensive electronic system which is able to do arithmetic and handle general data, the wisdom of establishing a degree program in this area is even more questionable. If the computer engineer is to be able to handle computer design he will need all of the work in electrical engineering and mathematics as a starter. To train a computer specialist who does not have the general background but who more nearly becomes skilled only in programming in various languages is more akin to training a skilled machinist or tool maker than an engineer. The potential disadvantage of such specialization for the student in the long term must then be coupled with the expense of setting up an academic structure to offer such curricula. Especially at the under-

graduate level, it is the writers' opinion that sound educational practice as well as economics dictates that the number of curricula be minimized and, repeating, that the education be rigorous and broadly based.

As opposed to continued splintering of curricula, the engineering profession needs stability and maturity as it attempts to solve its internal problems and as it continues to contribute in an extensive way to the solution of the real problems of society.

Regarding Graduate Education

At the graduate level for both the M.S. and Ph.D. the students should be required to continue on a broad base while obtaining perspective and understanding. This is especially necessary for students who work straight through for advanced degrees with a minimum of exposure to industry and actual engineering problems. Extreme specialization even at this level should be primarily obtained through the thesis or dissertation work of the student wherein the student is required to demonstrate an ability to discover or understand an important question, document it, and to perhaps achieve a solution to it.

The merit of and need for extensive education beyong the B.S. is clearly documented. Briefly, it may be full or part time, in engineering or in a different new field, preferably for degree credit at least for younger engineers, and, probably, most of all a way of life in an enlightened society if maximum contributions and rewards are to be achieved.

At the same time the students, faculties, and universities in cooperation with industry must achieve generalization by participation in pro-

fessional, industrial, and, say, civic groups. Such generalized participation ultimately becomes a service to society on behalf of engineers and of mutual benefit.

Research and Development - The Future

While, from the operating point of view, the need for engineers at a utility such as Union Electric has been and will be fairly uniform, the recent emphasis on conservation of resources and our environment provides possible new opportunities for engineers. The great need to conserve limited resources and to provide alternate fuels to supply our long-term energy needs provides challenges that are almost unlimited in scope. Consider, for example, fission, fast-breeders, fusion, direct energy conversion, geothermal, sea thermal, and solar energy forms which may be part of the solution to the long-term energy supply problem. Couple this problem with the need to assure a long-term and at least adequate environment for a population that no doubt will, at least for a while, increase in numbers while at the same time presumably exert a pressure for continuing higher standards of living.

In this setting with the great challenges that are real as opposed to those that are contrived, say by politicians or intervenors, the opportunities for broadly and substantially educated engineers would seem to be almost without limit. Thus the young engineer that has received a rigorous, substantial engineering education and who then has the courage, fortitude and patience to work and achieve in the solution of these worthwhile problems, would seem to have great opportunities. Correspondingly, because of the unknown associated with the

future, it is difficult to associate the opportunities for success in later life with too finely splintered curriculum options in educational programs at the various degree levels.

As many may know the utilities are right now embarking on an exciting Research and Development program and the writers feel that a brief review of its projected scope may provide the best insight into future requirements for engineers at all degree levels.

Union Electric is enthusiastically supporting this program which it considers to be a historic and monumental effort and which once again will demonstrate the ingenuity and creativity of man and his ability to cooperate for the common good. One of the early comprehensive reports, Electric Utility Industry Research and Development Goals through the Year 2000,[4] which was published in 1971 by the Goals Task Force for the Electric Research Council, gives a broad overall viewpoint.

The Report lists research needs in energy conversion, transmission and distribution, environment, and utilization at an expenditure of approximately $32 billion. It estimates that 11,000 man years per year for each of the next thirty years will be required at a cost of $50,000 per scientist-engineer man year. Almost every branch of science and engineering is represented in the program.

The electric utility industry next established a research arm, The Electric Power Research Institute (EPRI) to implement its

research program. Close cooperation among EPRI, the operating utilities, research institutes, universities and government agencies is essential if the research effort is to be beneficial.

The operating electric utilities participate in this research program by contributing money from revenue according to a formula and by providing personnel to serve on various advisory committees and task forces. The Research Projects Committee of Edison Electric Institute (EEI) which formerly guided the research program of EEI companies has been disbanded, but many other EEI committees and committee members assist in the research program.

The scope and depth of EPRI research and development activities is indicated by the following material which was taken from a recent working draft of a proposed 5-year plan.[5] Final data will be available in the future, however the following excerpts should help provide some understanding of the research mode of electric utilities.

ELECTRIC POWER RESEARCH INSTITUTE

PROGRAM PLAN
1975 - 1979

Introduction

During the first quarter of this year, the Institute's technical staff has worked closely with the EPRI utility industry advisory committees to develop a five-year research and development plan which will be responsive to current and future needs of the utility industry. This draft -------

In April 1975 the EPRI Research Advisory Committee will meet with the Institute's senior technical staff to review the draft five-year plan in terms of its balance, technical content, and overall level of effort. Following this ---------

Given the many requirements and broad interests of the electric utility industry, the potential for valuable research and development is almost unlimited. It was, therefore, essential to review and screen the many desirable programs to arrive at a manageable program. We believe that the procedure used in preparing this plan has resulted in a set of practical programs that will provide financial benefits to the utility industry in the coming years. In developing the five-year plan, the staff has benefited substantially from the many inputs that were received from the various advisory committees. Of particular importance were perceptions of the industry's needs developed as a res t of the Research Advisory Committee's workshop held in Monterey in July 1974. Other important inputs were obtained from the Advisory Council, divisional committees, task forces, discussion

with federal agencies, and contracts with foreign utility organizations. It should be recognized that these plans must contain a significant degree of flexibility to allow for research and development progress. Either positive or negative results can substantially alter the relative priorities of the various programs. It is intended that this information be updated each year to accommodate such changes as would be necessary in program emphasis.

Twenty-four programs and 130 subprograms are presented in this document. Each program is described in terms of objectives, key events and estimated funding levels. The programs included in this plan are as follows:

Fossil Fuel Department

Gasification
Liquefaction
Direct Utilization
Environmental Control and Combustion
Resource Extraction and Utilization
Supporting Research

Advanced Systems Department

Electrochemical
Thermal-Mechanical
Fusion
Solar
Geothermal

Nuclear Power Division

Water Reactor System Technology
Reliability, Availability, and Economics
Fuels, Waste, and Environment
Developing Applications and Technology

Transmission and Distribution Division

AC Overhead Transmission
Underground Transmission

DC Transmission
System Planning, Security and Control
Distribution Systems

Energy Systems, Environment and Conservation Division

Environmental Assessment
Energy Supply
Energy Demand and Conservation
Energy Modeling

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Mid-Range Goals - 1985 to 2000

Programs directed toward mid-range goals include such efforts as Coal Gasification, Coal Liquefaction, Liquid Metal Fast Breeder Reactor and Energy Storage Systems. The goals for this time frame are:

Goal	Applicable Programs
Ensure the efficient use of the nation's vast coal resources	Gasification Liquefaction Direct Utilization
Improve the use of available fissionable material and aid in the introduction of the LMFBR	Nuclear - Developing Application and Technology
Make available reliable, high-efficiency, low-cost conversion systems for base-load intermediate, and peaking application	Electrochemical Conversion and Storage Thermal-Mechanical Conversion and Storage Geothermal
Provide transmission and distribution equipment technology that will permit the efficient and highly reliable transport of electricity from source to consumer	All Transmission and Distribution
Provide systems and equipment that will permit the economic storage of energy	Electrochemical Conversion and Storage Thermal-Mechanical Conversion and Storage

Goal	Applicable Programs
Continue to develop information to assess the environmental and safety effects of various technical options	Environmental Assessment Environmental Control and Combustion
Ensure the avilability of information and technology to meet regulatory requirements	Environmental Assessment Water Reactor System Technology Environmental Control and Combustion
Achieve more desirable environmental and aesthetic conditions in electric power systems	Essentially all programs (about 50% of the Institute's effort)
Analyze the interrelation between technical performance objectives and the economics of electricity supply, and apply the results to the research and development program	Energy Demand and Conservation Energy Supply Energy Modeling Environmental Assessment

Long-range Goals - 2000 and beyond

The Institute's long-range goals center around the development of technologies that will permit economical generation of electricity from renewable energy resources. Emphasis will, however, remain focused on improved conversion efficiencies to mitigate waste heat disposal problems and to conserve nonrenewal resources. System and plant siting requirements in this period could also necessitate the development of significantly new methods to transport large amounts of electricity. The Institute's long-range goals are, therefore, to:

Goal	Applicable Programs
Develop the technology needed to apply the essentially unlimited energy resources such as breeder reactors, fusion systems, and solar energy	Nuclear - Developing Applications and Technology - Fast Breeder Reactor Fusion Solar
Continue to develop high-efficiency generation equipment and technology for use with both nonrenewable and renewable resources	Thermal-Mechanical Conversion and Storage

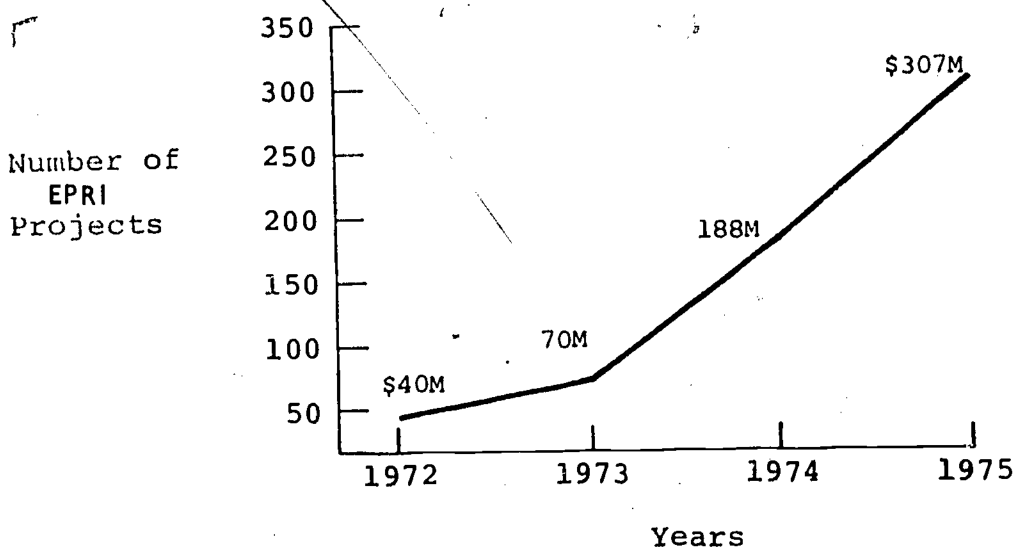
Goal	Applicable Programs
Develop cost effective transmission and distribution systems that will permit greater flexibility in the location of power plants	Transmission & Distribution Cryogenic and Superconducting Transmission
Continue to provide information that will assure a balance among national economic factors, environmental effects, and technological options	Energy Demand & Conservation Energy Supply Energy Modeling Environmental Assessment

Some Typical Research Projects are:

ENVIRONMENTAL ASSESSMENT DEPARTMENT PROGRAM PLANNING[6]
II. TRANSPORT AND INTERACTIONS

Project No.	Subject, Organization, Principal Investigator
RP 330	Atmospheric Interactions in a Coal Fired Power Plant Plume; Univ. of Washington (P.V. Hobbs)
RP 382	SO_2 Conversion on Oil Fired Plume Particulates-Lab. Study; SUNY, Albany (V. Mohnen)
RP 438	Computerized Pattern Recognition for Air Quality Analysis; Univ. of Arizona and Purdue (J.L.Moyers & S. Perone)
RP 484	Airborne Monitoring of Cooling Tower Effluents; State of Maryland (J. Pell)
RP 485	Sulfate Regional Experiment; Environmental Res. & Technology (G.M. Hidy)
RP 487	Time-Variable Air Resources in the Northern Great Plains; TRC of New England (G.Hilst)
ES3129	Data Characterization for Air Qual.Models;Xonics (R.Sklarew)
ES3148	Monitoring & Modeling Oxidant Formation in Western Power Plant Plumes;MRI & Sys. Applications,Inc.(D.Blumenthal & P.Roth)
ES3101	Monitoring & Modeling Oxidant Formation in Eastern Power Plant Plumes; Univ. of Maryland (D. D. Davis)

In a speech[7] at the Annual Convention of the Edison Electric Institute on June 4, 1975, Dr. Chauncey Starr, President of EPRI, presented the following summary data.



(1)

EPRI 1975 R & D EMPHASIS

	Percent of 1975 Funding
Short-range goals (to 1985)	50
Mid-range goals (1985-2000)	40
Long-range goals (2000 and beyond)	10

(2)

EPRI MOTIVATION FOR RESEARCH

Percent Emphasis	
1.0	To assess future supply and demand
6.8	To facilitate research planning
42.9	Environmental protection, public health, and safety
26.7	To increase energy supply
12.9	To increase reliability
9.7	To increase efficiency, conservation

(3)

Percent Funding	EPRI FUNDING BY TYPE OF RESEARCH
67.6	Hardware development and testing
21.9	Analytic studies
9.1	State-of-the-art assessments, concepts development
1.4	Software development and testing

(4)

Percent Funding	EPRI FUNDING BY TYPE OF CONTRACTOR
1.3	Government
10.2	Utility
11.6	University
9.6	For-profit consultants
61.8	Commercial and industrial
5.5	Not-for-profit

(5)

ADVISORY INPUTS TO EPRI PLANNING PROCESS

Public

Advisory Council

NARUC

EPRI

Utility Industry

EPRI Industry Committees

AEIC NERC

APPA NRECA

EEI

Foreign Utilities

Federal Agencies

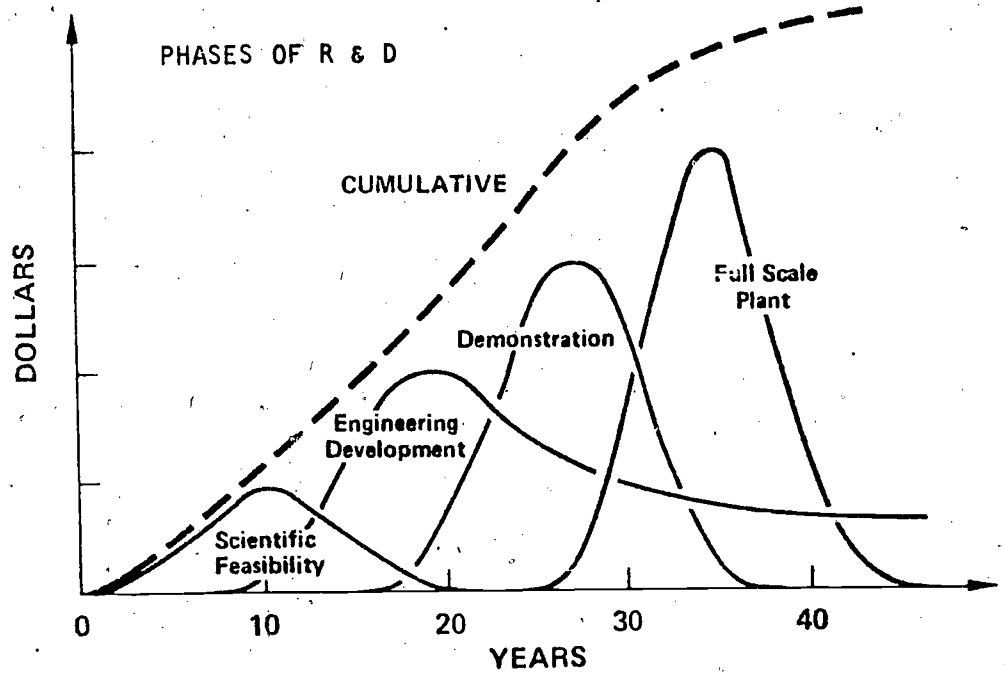
DOI FPC

ERDA NASA

EPA NRC

FEA OTA

(6)



(8)

Fusion Program	Investment ($ billions)
. Scientific feasibility stage	
Analytical	$ .5
Experimental	2.0
. Engineering feasibility	
Bench scale	4.0
Intermediate demonstration	10.0
. Initial full-scale introduction	5.0
Total:	$ 21.5

(9)

Clean Fuel Program	Gasification ($ billions)	Liquefaction
. Scientific feasibility	completed	completed
. Engineering feasibility	$ .3	$ .3
. Bench scale, testing, and pilot plant	-	-
. Full-scale introduction	1.5	1.2
	$ 1.8	$ 1.5

Total: $3.3 billion (10)

Concluding Comments

This paper briefly offered some opinions about engineering education, certain future manpower requirements, electric utility problems and needs, and a massive energy Research and Development effort. Providing energy will require maximum cooperative efforts of all concerned in our society

While certain weaknesses and problems exist in our country and the world at various levels within and without the utilities, the writers are basically very optimistic about the future and our chances for continually improving the quality of life for mankind. With the cooperation of an increasingly enlightened public, of a more aware and responsive industry, of an appropriately tempered government, and of our universities, the struggle to solve important problems of mankind can be continued with increased hope and chances for success. Engineering expertise must continue to play an important role in the solution of our real problems, and our engineering schools are urged to continue and even increase their contribution and influence in the solution of these problems.

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6. From a 1975 American Power Conference Presentation by Dr. H. Kornberg of the Electric Power Research Institute.

7. From a speech at the Annual Convention of the Edison Electric Institute on June 4, 1975, by Dr. Chauncey Starr, President of the Electric Power Research Institute.

GED/kc 6/5/75

SUMMARY
ELECTRIC UTILITY MANPOWER SURVEY — EXHIBIT "A"
EDISON ELECTRIC INSTITUTE

1. NUMBER OF COMPANIES RESPONDING

1967 - 110
1971 - 115

2. PRESENT ENGINEERING GRADUATES

1967	16,923	[EE-10,624	ME-3,468	OTHER-2,831]
1971	18,184	[EE-10,369	ME-3,670	OTHER-4,039]

3. ENGINEERING TURNOVER

1967 SURVEY	1971 SURVEY
1962 - 600	
1963 - 623	
1964 - 624	
1965 - 806	
1966 - 986	1966 - 829
	1967 -1521
	1968 -1599
	1969 -1714
	1970 -1359

4. ENGINEERING HIRES BY DEGREE LEVEL

1967 SURVEY

	BS	MS	PHD
1962-	700	10	1
1963-	809	15	1
1964-	974	27	1
1965-	925	31	1
1966-	828	44	1
	4,236	127	5

1971 SURVEY

	BS	MS	PHD
1966 -	759	48	1
1967 -	906	59	2
1968 -	1162	101	8
1969 -	1382	132	11
1970 -	1943	191	27
	6152	531	49

5. ENGINEERING GRADUATE NEEDS IN THE FUTURE

1967 SURVEY -

	BACHELOR DEGREE EE	ME	OTHER	TOTAL	MASTER DEGREE	DOCTORATE	TOTAL
1967-1971	3,593	1,139	514	5,246	351	20	5,617
1972-1976	3,174	1,063	585	4,822	402	25	5,432

1971 SURVEY -

	EE	ME	OTHER	TOTAL	MASTER DEGREE	DOCTORATE	TOTAL
1971-1975	3,072	1,373	1,038	5,483	445	51	5,989
1976-1980	3,146	1,465	1,133	5,744	480	59	6,283

EXHIBIT "B"

6. TECHNICIAN NEEDS IN THE FUTURE

1967 SURVEY

	ENGINEERING	OTHER	TOTAL
1967-1971	2,938	2,234	5,172
1972-1976	2,986	2,394	5,380

1971 SURVEY

	ENGINEERING	OTHER	TOTAL
1971-1975	1,655	1,544	3,259
1976-1980	1,621	1,605	3,226

7. ENGINEERING GRADUATES - BY CLASS STANDING

	UPPER QUARTER	SECOND QUARTER	LOWER HALF	TOTAL
1967 SURVEY	554	1,097	1,117	2,768
1971 SURVEY	888	1,310	,669	2,767

8. GENERAL OBSERVATIONS

a. The population of electrical engineers and mechanical engineers has remained relatively stable, both in total numbers and relationship to each other. The number of other engineers employed by the industry (nuclear, etc.) has grown somewhat.

b. The number of advanced engineering degrees employed by the industry, and forecast as required, has increased. This is in line with the predictions made by the Task Force on Engineering Manpower Needs in 1968.

c. The forecast requirements for technicians (engineering and total) has decreased.

d. The number of engineering schools, from which the industry draws graduates, has increased.

e. The number of graduates of foreign engineering schools has increased.

f. Measured by their standing in graduate class of reporting companies, the quality of engineering graduates employed by the industry appears to have improved.

*Note: Pages 29 and 30 are copies of an E.E.I. Survey.